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Author: Kwan Jennifer M. MD, PhD; Noch Evan MD, PhD; Qiu Yuqing MS; Toubat Omar , PhD; Christophers Briana; Azzopardi Stephanie; Gilmer Gabrielle; Wiedmeier Julia Erin MD, MPH; Daye Dania MD, PhD

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The Impact of COVID-19 on Physician-Scientist Trainees and Faculty in the United States: A National Survey

Jennifer M. Kwan, MD, PhD, Evan Noch, MD, PhD, Yuqing Qiu, MS, Omar Toubat, PhD, Briana Christophers, Stephanie Azzopardi, Gabrielle Gilmer, Julia Erin Wiedmeier, MD, MPH, and Dania Daye, MD, PhD

J.M. Kwan is a cardiologist, Yale School of Medicine, New Haven, Connecticut, and director, Board of Directors, American Physician Scientists Association, Westford, Massachusetts; ORCID ID: https://orcid.org/0000-0002-4715-1848.

E. Noch is a neurologist, Weill Cornell School of Medicine, New York , New York, and director, Board of Directors, American Physician Scientists Association, Westford, Massachusetts; ORCID: https://orcid.org/0000-0002-4561-1169.

Y. Qiu is a biostatistician, Weill Cornell School of Medicine, New York , New York; ORCID: https://orcid.org/0000-0002-4561-1169.

O. Toubat is an MD-PhD student, University of Southern California, Los Angeles, California; ORCID: https://orcid.org/0000-0002-3377-1384.

B. Christophers is an MD-PhD student, Weill Cornell Medicine, New York , New York; ORCID: https://orcid.org/0000-0001-5248-069X.

S. Azzopardi is an MD-PhD student, Weill Cornell Medicine, New York , New York; ORCID: https://orcid.org/0000-0002-9585-9234.

G. Gilmer is an MD-PhD student, University of Pittsburgh, Pittsburgh, Pennsylvania; ORCID: https://orcid.org/0000-0002-9039-4183.

J.E. Wiedmeier is a hematology/oncology fellow, Mayo Clinic Arizona, Phoenix, Arizona; ORCID: https://orcid.org/0000-0001-9434-5269.

D. Daye is an interventional radiologist, Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts, and director, Board of Directors, American Physician Scientists Association; ORCID: https://orcid.org/0000-0002-2230-7199.

The authors have informed the journal that they agree that both Jennifer M. Kwan and Evan Noch completed the intellectual and other work typical of the first author.

Correspondence should be addressed to Jennifer M. Kwan, Yale School of Medicine, Section of Cardiovascular Medicine, 789 Howard Avenue, FMP 330, New Haven, CT 06519; email: jennifer.kwan@physicianscientists.org; Twitter: @jennkwanmdphd.

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Abstract

Purpose

Physician-scientists have long been considered an endangered species, and their extended training pathway is vulnerable to disruptions. This study investigated the effects of COVID-19-related challenges on the personal lives, career activities, stress levels, and research productivity of physician-scientist trainees and faculty.

Method

The authors surveyed medical students (MS), graduate students (GS), residents/fellows (R/F), and faculty (F) using a tool distributed to 120 U.S. institutions with MD-PhD programs in April–June 2020. Chi-squared and Fisher's exact tests were used to compare differences between groups. Machine learning was employed to select variables for multivariate logistic regression analyses aimed at identifying factors associated with stress and impaired productivity.

Results

The analyses included 1,929 respondents (MS: n = 679, 35%; GS: n = 676, 35%; R/F: n = 274, 14%; F: n = 300, 16%). All cohorts reported high levels of social isolation, stress from effects of the pandemic, and negative impacts on productivity. R/F and F respondents were more likely than MS and GS respondents to report financial difficulties due to COVID-19. R/F and F respondents with a dual degree expressed more impaired productivity compared to those without a dual degree. Multivariate regression analyses identified impacted research/scholarly activities, financial difficulties, and social isolation as predictors of stress and impaired productivity for both MS and GS cohorts. For both R/F and F cohorts, impacted personal life and research productivity were associated with stress, while dual-degree status, impacted research/scholarly

activities, and impacted personal life were predictors of impaired productivity. More female than male respondents reported increased demands at home.

Conclusions

This national survey of physician-scientist trainees and faculty found a high incidence of stress and impaired productivity related to the COVID-19 pandemic. Understanding the challenges faced and their consequences may improve efforts to support the physician-scientist workforce in the post-pandemic period.

COVID-19 has infected more than 80 million people and killed more than 900,000 people in the United States as of April 2022.[1] To combat this virus, physician-scientists—physicians who spend the majority of their time conducting research—have been redeployed to provide care for the large influx of infected patients. Many have pivoted their research to address the pathophysiology of the virus to aid in the development of viable treatments and vaccines. While physician-scientists are well positioned to address these aspects of the COVID-19 pandemic and the long-term health consequences of COVID-19,[2] they are also vulnerable to disruptions in their training paths and careers. Prior to the pandemic, they were already considered an endangered species whose ranks have been declining over the past several decades.[3,4] Disruptions start at the beginning of the physician-scientist pathway, at the medical student level, and continue all the way to the faculty level, with residents/fellows and early-career faculty being particularly vulnerable.

For medical students, COVID-19 restrictions led to reduced hands-on learning experiences during the initial peak of the pandemic and deferral of standardized exams.[5] For physician-scientist trainees entering their graduate school research phase, COVID-19 restrictions posed challenges for transitioning out of the preclerkship phase of medical school and into the laboratory (lab) and for gaining exposure to different lab environments when in-person lab rotations were significantly limited.[5] Graduate students who were finishing up their research faced interruptions to their research progress, particularly for wet lab work and animal experiments.[6]

For residents, fellows, and faculty, the pandemic has posed additional challenges, including not being able to find a desired research position, compromised training opportunities, and reduced productivity as research stalled.[7-9] The rise of COVID-19 has disrupted the entire biomedical

research enterprise, from halted clinical trials to reduced research capacity in labs and redirection of resources to combat COVID-19.[10-13] In addition to these disruptions, COVID-19 has led to increased levels of stress, social isolation, depression, burnout, and suicide among health care providers,[14-19] and it has affected the well-being, health, productivity, and training of residents, fellows, and physician-scientist faculty.[20-22]

Prior to the COVID-19 pandemic, several factors emerged as key contributors to decreased productivity and increased attrition of physician-scientists at the resident, fellow, and early-career faculty level, including work-life balance, grant acquisition, institutional pressures for clinical productivity, and financial stressors.[23,24] During the pandemic, women have been disproportionately affected by increased caregiving demands and home-related duties that have subsequently reduced their career productivity.[25-29] Identifying the ways and extent to which the COVID-19 pandemic has affected physician-scientists and trainees is critical if we are to retain them to address biomedical research problems, including tackling long COVID.[30] Therefore, in this study, we investigated the impact of COVID-19 on the personal lives, career activities, stress levels, and research productivity of physician-scientist trainees and faculty.

Method

We designed a survey tool with feedback from mental health researchers and academic faculty with expertise in training physician-scientists. The 3 versions of the survey included different numbers of questions, according to training level: 13 for medical students, 17 for graduate students, and 18 for residents/fellows and faculty. Medical students doing their graduate research training in a combined or separate science degree-conferring program were defined as graduate students in this study. The survey instrument (with the questions for the 3 versions) is available as Supplemental Digital Appendix 1 at http://links.lww.com/ACADMED/B297.

From April 14 to June 26, 2020, the survey was distributed to 120 U.S. institutions with MD-PhD programs by the chairs of the Association of American Medical Colleges' Group on Graduate Research, Education and Training (GREAT) and by institutional representatives of the American Physician Scientists Association. The survey was administered via SurveyMonkey (Momentive, San Mateo, California). This study was approved as exempt by the Weill Cornell Medicine Institutional Review Board.

There were 2,100 responses, but after filtering for responses with significant missing data, 1,929 total respondents were included in the analyses. Standard biostatistical analyses were performed, including chi-squared and Fisher's exact tests, to compare differences between groups. An elastic net machine learning method was used to select variables for multivariate logistic regression analyses to determine significant differences between independent variables for the outcomes of stress and impaired productivity. The stress outcome was defined by answering "agree" or "strongly agree" to one or more of the following questions in the survey: "The COVID-19 pandemic has caused me a significant amount of stress, anxiety, hopelessness and/or depression," "The COVID-19 pandemic has caused sleep problems, decreased energy, changes in appetite, difficulty concentrating and/or restlessness," "Uncertainty of not being able to finish my research or to graduate is a great source of stress," and "Worrying about my own health is a great source of stress." The impaired productivity outcome was defined as answering "agree" or "strongly agree to at least one of the following questions: "My research productivity/medical training will be negatively impacted in the short-term (< 2 months)" and "My research productivity/medical training will be negatively impacted in the long-term (> 2 months)."

For the demographic variables, respondents self-defined their gender as female, male, or other and self-described their racial/ethnic identity as White, Black or African American, Asian, Hispanic/Latino(a), or other. When specialty data were analyzed, respondents' specialties were grouped according to the categories shown in Supplemental Digital Table 1 at http://links.lww.com/ACADMED/B298. Multivariate regression results were presented using forest plots. Results were deemed significant if $P < .05$. All analyses were performed in R, using R programming language version 4.1.2 (2021-11-01; R Core Team, Vienna, Austria) and RStudio (Integrated Development for R) by RStudio Team (2020; Boston, Massachusetts).

Results

Demographic and professional characteristics of the 1,929 respondents from 120 U.S. institutions with MD-PhD programs are summarized in Table 1. There were 679 (35%) medical student (MS), 676 (35%) graduate student (GS), 274 (14%) resident/fellow (R/F), and 300 (16%) faculty (F) respondents. Dual-degree status was indicated by 73% (n = 495) of MS, 96% (n = 648) of GS, 64% (n = 175) of R/F, and 36% (n = 109) of F respondents. Female respondents represented 55% (n = 370) of MS, 52% (n = 349) of GS, 45% (n = 121) of R/F, and 52% (n = 156) of F respondents. The majority of respondents were White, followed by Asian. Black/African American and Hispanic respondents were represented at lower proportions across all groups. Regionally across the United States, most MS (34%, n = 229), GS (30%, n = 204), and R/F (43%, n = 119) respondents were from institutions in the Northeast. Most faculty respondents were from institutions in the South/Southeast (48%, n = 143). Faculty respondents spanned career stages, as stratified by age: Junior or early-career faculty (< 40 years old) made up 58% (n = 173), intermediate faculty (40–50 years old) made up 28% (n = 84), and senior faculty (≥ 51

years old) made up 14% (n = 43) of F respondents. R/F and F respondents differed in terms of specialties (Supplemental Digital Table 2 at http://links.lww.com/ACADMED/B298).

All 4 cohorts reported academic and training disruptions caused by COVID-19, including effects on their training/education and their ability to conduct research/scholarly activity (Table 1). All cohorts also reported effects of the pandemic on their personal lives and well-being, with high levels of social isolation (MS: n = 300, 44%; GS: n = 456, 67%; R/F: n = 163, 59%; F: n = 181, 60%) and stress (MS: n = 552, 81%; GS: n = 583, 86%; R/F: n = 222, 81%; F: n = 253, 84%). R/F and F respondents were significantly more likely than MS and GS respondents to report financial difficulties (MS: n = 193, 28%; GS: n = 225, 33%; R/F: n = 99, 36%; F: n = 133, 44%[$P < .001$]) and a history of being infected by or having symptoms of COVID-19 (MS: n = 48, 7%; GS: n = 55, 8%; R/F: n = 44, 16%; F: n = 41, 14% [$P < .001$]). Given the high rates of stress and of negative impacts on research productivity (MS: n = 487, 72%; GS: n = 572, 85%; R/F: n = 183, 67%; F: n = 191, 64%), we performed a subgroup analysis of respondents by these categories (Tables 2 and 3; also Supplemental Digital Tables 3 and 4 at http://links.lww.com/ACADMED/B298).

Impact on stress

In both the MS and GS cohorts, respondents who identified as having stress were more likely than their peers to perceive their careers as being affected ($P < .001$ for both). They were also more likely to describe COVID-19 as impacting their ability to conduct research/scholarly activities ($P < .001$ for both) and their research productivity as being affected by COVID-19 ($P < .001$ for both). Among MS respondents, those who were infected or had symptoms of COVID-19 and those who identified as females reported more stress (COVID-19: $P = .002$; female gender: $P = .013$). For GS respondents, research characteristics, such as research field (biological

sciences vs computer and information science and engineering vs mixed/none, $P < .001$) and lab type (only dry vs only wet vs mixed/none, $P < .001$), were also associated with stress (Table 2; Supplemental Digital Table 3 at http://links.lww.com/ACADMED/B298).

Dual-degree R/F respondents were more likely than single-degree R/F respondents to report stress ($P = .001$) (Table 2; Supplemental Digital Table 3). All R/F and F respondents who changed their research or specialty, had financial difficulties, or became infected/had symptoms of COVID-19 reported stress (R/F: $P < .001$; F: $P < .01$). Among all R/F and F respondents who reported stress, patient care, personal life, research/scholarly activity, research productivity, social isolation, and training/education were all negatively affected (Table 2; Supplemental Digital Table 3).

We performed a multivariate regression analysis to identify common and unique factors associated with stress among respondents (Supplemental Digital Figures 2 and 3 http://links.lww.com/ACADMED/B299). For both the MS and GS cohorts, impacted research/scholarly activity (MS: OR 5.32, 95% CI 3.14-9.34, $P < .001$; GS: OR 9.03, 95% CI 4.59-18.11, $P < .001$), financial difficulties (MS: OR 6.87, 95% CI 3.15-17.37, $P < .001$; GS: OR 2.69, 95% CI 1.31-5.99, $P = .01$), and social isolation (MS: OR 23.25, 95% CI 10.01-67.98, $P < .001$; GS: OR 4.57, 95% CI 2.54-8.4, $P < .001$) were associated with stress. For both R/F and F cohorts, effects on personal life (RF: OR 7.24, 95% CI 1.67-35.9, $P = .009$; F: OR 115.9, 95% CI 21.23-1231.69, $P < .0001$) and research productivity (RF: OR 7.88, 95% CI 1.79-41.95, $P = .008$; F: OR 24.71, 95% CI 3.24-596.19, $P = .009$) were associated with stress. Effects on patient care (OR 20.97, 95% CI 5.02-102.1, $P < .001$) and social isolation (OR 6.55, 95% CI 1.45-33.46, $P = .016$) were predictive of stress among R/F respondents, whereas effects on

training/education activities (OR 100.65, 95% CI 11.55-2910.1, $P < .001$) were a significant predictor of stress among F respondents (Supplemental Digital Figure 3).

Impact on productivity

We next evaluated characteristics of respondents who reported their productivity as being negatively affected by COVID-19 (Table 3; Supplemental Digital Table 4 at http://links.lww.com/ACADMED/B298). For MS respondents, more of those who perceived their training/education ($P < .001$) and career ($P = .006$) as being affected reported impaired productivity compared to those who did not. For GS respondents, region ($P = .082$), dual-degree status ($P < .027$), lab type ($P < .001$), and research field ($P < .001$) were associated with impaired productivity. In both MS and GS cohorts, we found that conducting research/scholarly activity, financial difficulties, personal life impact, social isolation, and stress were all associated with impaired productivity ($P < .001$ for all variables).

For R/F and F respondents, there was a statistically significant difference in the mean age of R/Fs (Table 1). More females (n = 26/273, 10%) than males (n = 8/295, 3%) reported that they had increased home demands, including homeschooling, being primary caretakers for children, and spending more time taking care of home-related tasks (Supplemental Digital Figure 1 at http://links.lww.com/ACADMED/B299). R/F and F respondents with a dual degree expressed more impaired productivity compared to those without a dual degree ($P < .001$ for both). Those R/F and F respondents with impaired productivity also indicated that the pandemic affected their patient care and their personal lives and caused stress ($P < .001$ for all variables).

In multivariate regression analyses, financial difficulties (MS: OR 2.01, 95% CI 1.27-3.26, $P = .004$; GS: OR 3.14, 95% CI 1.67-6.3, $P < .001$) and social isolation (MS: OR 4.1, 95% CI 2.69-6.37, $P < .001$; GS: OR 3.96, 95% CI 2.36-6.74, $P < .001$) were the only variables that were

associated with outcome of impaired productivity in both MS and GS respondents (Supplemental Digital Figure 2 at http://links.lww.com/ACADMED/B299). An effect on research/scholarly activities (MS: OR 3.0, 95% CI 2.04-4.47, $P < .001$) was associated with impaired productivity in the MS cohort, whereas wet lab research (GS: OR 2.91, 95% CI 1.23-6.78, $P = .013$) was predictive among GS respondents. Compared with wet lab research/biological sciences research, research in computer and information science and engineering (GS: OR 0.11, 95% CI 0.03-0.4, $P < .001$) was associated with lower odds of impaired productivity in GS respondents. For R/F and F respondents, dual-degree status (R/F: OR 2.61, 95% CI 1.17-5.98, $P = .02$; F: OR 2.45, 95% CI 1.03-6.06, $P = .046$), an impact on research/scholarly activities (R/F: OR 2.82, 95% CI 1.14-7.57, $P = .03$; F: OR 26.22, 95% CI 10.31-77.35, $P < .001$), and an impact on personal life (R/F: OR 2.46, 95% CI 1.14-5.36, $P = .022$; F: OR 2.84, 95% CI 1.33-6.15, $P = .007$) were predictors of impaired productivity.

Regional differences

Given the regional differences in the burden of COVID-19 at the time of survey completion in April–June 2020, we performed an additional subgroup analysis comparing the impact of the pandemic on respondents by region. For MS respondents, there were regional differences in the option for early medical school graduation ($P = .008$), changing research efforts to focus on COVID-19-related topics ($P < .001$), and changing intended career path/specialty as a result of COVID-19 ($P < .001$). For GS respondents, there were regional differences in the personal and educational effects of the pandemic, including labs being shut down ($P = .008$) and experiments being delayed or impaired ($P = .004$). All regional response variables for MS and GS respondents are presented in Supplemental Digital Tables 5 and 6, respectively, at http://links.lww.com/ACADMED/B298.

Among F respondents on a tenure track, 26% (n = 48) in the South/Southeast and 17% (n = 33) in the Northeast reported their institutions reset the tenure clock due to the pandemic. However, only 6% of respondents at institutions in the Midwest (n = 4) and on the West Coast (n = 5), reported this change to the tenure clock. Regarding clinical duties, R/F and F respondents from the Midwest (R/F: n = 18, 28%, $P < .001$; F: n = 12, 60%, $P < .001$) and Northeast (R/F: n = 62, 53%, $P < .001$; F: n = 70, 63%, $P < .001$) were more likely than those from other regions to report that their institutions redeployed clinicians from other specialties to assist with COVID-19-related care. While there was a higher proportion of R/F respondents who reported receiving hazard pay from their institutions in the Northeast (n = 14, 12%, P = .001), the total number of R/F respondents receiving hazard pay was low among all respondents (n = 15, 6%, $P = .001$). All regional response variables for R/F and F respondents are presented in Supplemental Digital Table 7 at http://links.lww.com/ACADMED/B298.

Additional variables

Additional data regarding the impact of COVID-19 on personal lives, scholarly activities, child care, transportation challenges, and other variables among R/F and F respondents are summarized in Supplemental Digital Tables 8-12 at http://links.lww.com/ACADMED/B298.

Discussion

This national study provides data on the personal, educational, and professional consequences of the COVID-19 pandemic for physician-scientist trainees and faculty in the United States, with strong representation of dual-degree trainees from the medical school to fellowship stages. The data presented here demonstrate that the pandemic had significant and comprehensive effects on stress and research productivity in this cohort. While many of the factors associated with stress and impaired productivity during the pandemic were similar among physician-scientist trainees

and physician-scientists, some varied slightly by geographic region and according to training or career stage. Key findings are summarized in Supplemental Digital Figures 2 and 3 (available at http://links.lww.com/ACADMED/B299).

Medical students

We identified differences in COVID-19 experiences between subgroups of medical students that warrant further attention. A significantly higher percentage of female students than male students reported experiencing stress in this study, which is consistent with prior studies describing increased stress in female versus male medical students.[31-33] Understanding this disparity is important considering that stress is a known risk factor for depression, burnout, and poorer overall mental health.[34] Moreover, a previous study evaluating risk factors for depressive symptoms in more than 6,000 U.S. adults, using the Patient Health Questionnaire-9 instrument, showed sex and gender differences in depression pre-pandemic and during COVID-19, with depression rates increasing from 10.1% to 33.3% in women and 6.9% to 21.9% in men.[35] Interestingly, in our study, while more female students reported stress compared with their male counterparts, they did not perceive changes in productivity compared with males. Our data were collected early in the pandemic, however. Follow-up studies are warranted to help explain the reduction in female-authored publications identified more recently in the pandemic.[25]

Social isolation was reported by nearly half of medical student respondents and, importantly, served as an independent predictor of stress and impaired productivity in this cohort. This finding may reflect broader issues surrounding mental health among medical students, such as an estimated 27% prevalence of depression and 11% prevalence of suicidal ideation.[36] Especially during the COVID-19 pandemic, it is essential for medical schools to provide adequate health and wellness resources to address mental health issues while overcoming medical students' fear

of stigmatization and concerns about confidentiality.[37] Returning to in-person events, such as lectures and graduations, may also help reduce social isolation.

The majority of medical students reported that their productivity would be affected. Financial difficulty and social isolation were 2 factors that predicted impaired productivity. While the National Institutes of Health maintained stipends for medical scientist training programs during the pandemic,[38] not all physician-scientist trainees receive this funding. Institutions should make funds available on an as-needed basis as a grant/scholarship option to help those who are experiencing financial difficulty.

Graduate students

We found that career and research pursuits, financial challenges, and social isolation were all associated with stress among graduate students. In terms of productivity, graduate students reported impaired productivity if they experienced financial difficulties and social isolation. This finding, coupled with our stress outcome findings, suggest that the COVID-19 pandemic may have increased burnout in this population.[39] Institutional support may be one mechanism to address burnout, as it has been shown to improve students' mental health.[40] The use of validated modules to assess student health and wellness may also be helpful for programs to consider as we transition out of the pandemic.[41,42] To help address trainees' concerns about the impact of the pandemic on their careers and research, programs should consider flexibility in their requirements and transparency about these flexible options.[43-45] Additionally, because we found that graduate students performing only wet lab and/or biological sciences research reported that their research was affected (likely driven by the difficulty in transitioning this type of work to the virtual setting), funders offering award extensions should consider longer extensions for wet lab- and/or biological sciences-related research.

Residents/fellows and faculty

Residents/fellows and faculty reported high levels of stress and impaired productivity as a result of the COVID-19 pandemic. Factors independently associated with stress included social isolation, impact on personal life, and impact on research productivity. Having a dual degree was associated with impaired productivity. While being female was not independently predictive of stress or negative impacts on productivity, a subanalysis evaluating the impact of the pandemic on personal life found that more female than male respondents reported increased home demands on their time due to taking care of and/or homeschooling children. The disproportionate impact of child care duties on female scientists' careers has been described elsewhere; for example, Viglione found that female scientists published fewer papers and preprints in 2020 compared with 2019, in part due to the burden of child care duties during pandemic-related school closures.[25]

The results outlined here provide important insights into the adverse effects of the pandemic on physician-scientists at the resident/fellow and faculty levels and emphasize the need for tailored initiatives to protect this vulnerable population. If policies are not implemented to address these challenges, a generation of physician-scientists may be lost, which would have long-lasting effects that outlast the public health effects of the COVID-19 pandemic. Institutional initiatives, such as providing additional intramural funding to support research efforts or to assist with the costs of child care/caregiving as well as flexible work hours to accommodate child care, may help offset challenges associated with maintaining research productivity as we transition out of the pandemic.[46–48] Targeting these grants specifically at the most at-risk physician-scientists—including junior or early-career faculty, women, and individuals whose research efforts were most disrupted by the pandemic—may help ensure success of these vulnerable groups. Federal

agency, specialty society, and foundation grants that offer additional support (with budget flexibility to support and/or accommodate child care needs) to early-career and female investigators during this time could improve retention. Resetting the tenure clock may help offset the impact of COVID-19 on the career trajectory of individuals applying for tenure promotion and grant extensions due to impaired productivity as a result of COVID restrictions. In addition, formal mentors and mentoring programs specifically designed for residents/fellows, early-career faculty, and underrepresented in medicine and female physician-scientists may improve post-pandemic productivity. Previous studies have shown that targeted mentorship efforts for women in medicine, for example, have been associated with improved career satisfaction, faculty retention, and productivity.[49.50]

Limitations

This study has several limitations inherent in its cross-sectional design. The results reported here reflect a one-time assessment of the impact of COVID-19 on respondents' personal, educational, and professional experiences. A follow-up study is needed to evaluate changes over time. To improve the efficacy of supportive measures aimed at helping the physician-scientist workforce, future studies should examine the extent of stress and productivity changes and the percentage of time allocated to various professional and personal responsibilities during the pandemic. Finally, our survey was not designed to evaluate opinions on institutional or government policies or efforts to mitigate the stress and impaired productivity caused by the pandemic. Exploring diverse perspectives on how best to address physician-scientists' concerns and support their work are critical for the ultimate success of such policies and efforts. The strengths of this study include its multicenter design, the large and diverse cohort of respondents spanning the

continuum from medical and graduate students to residents/fellows and faculty, and the timing of the survey data collection, which coincided with the initial peak of the COVID-19 pandemic.

Conclusions

This national survey of physician-scientist trainees and faculty found that COVID-19 led to high levels of stress, aggravating factors that fueled physician-scientist attrition prior to the pandemic. Financial stressors were heightened for some respondents. More female than male respondents reported spending more time taking care of children and on home-related duties, which may reduce future grant and career success for women. There also appeared to be some regional differences in the direct impact of COVID-19 and in institutional policies responding to the pandemic. Disruptions to early-career physician-scientists' research puts society at risk of losing an entire generation of physician-scientists, at a time when we need them the most. Understanding the challenges faced and their associated factors may improve efforts to support the physician-scientist workforce in the post-pandemic period.

References

1. Centers for Disease Control and Prevention. COVID Data Tracker. https://covid.cdc.gov/covid-data-tracker/#trends_dailytrendsdeaths. Accessed March 5, 2021.
2. Yelin D, Wirtheim E, Vetter P, et al. Long-term consequences of COVID-19: Research needs. Lancet Infect Dis. 2020;20:1115-1117.
3. Jain MK, Cheung VG, Utz PJ, Kobilka BK, Yamada T, Lefkowitz R. Saving the endangered physician-scientist—A plan for accelerating medical breakthroughs. N Engl J Med. 2019;381:399-402.
4. Rosenberg LE, Ley TJ. The endangered physician-scientist: Opportunities for revitalization emerge. In: National Research Council. Bridging the Bed-Bench Gap: Contributions of the Markey Trust. Washington, DC: The National Academies Press; 2004.
5. Calco G, Erickson H, Toubat O, Spellicy S. MD/DO-PhD trainees: Flexing, adapting, and progressing during COVID-19. J Clin Transl Sci. 2020;5:1-7.
6. Servick K, Cho A, Guglielmi G, Vogel G, Couzin-Frankel J. Updated: Labs go quiet as researchers brace for long-term coronavirus disruptions. Science. https://www.science.org/content/article/updated-labs-go-quiet-researchers-brace-long-term-coronavirus-disruptions. Published March 16, 2020. Accessed April 12, 2022.
7. Myers KR, Tham WY, Yin Y, et al. Unequal effects of the COVID-19 pandemic on scientists. Nat Hum Behav. 2020;4:880-883.
8. Donthu N, Gustafsson A. Effects of COVID-19 on business and research. J Bus Res. 2020;117:284-289.

9. Del Rio C, Collins LF, Malani P. Long-term health consequences of COVID-19. JAMA. 2020;324:1723-1724.

10. Radecki J, Schonfeld RC. The Impacts of COVID-19 on the Research Enterprise: A Landscape Review. New York, New York: Ithaka S+R; 2020.

11. Weiner DL, Balasubramaniam V, Shah SI, Javier JR. COVID-19 impact on research, lessons learned from COVID-19 research, implications for pediatric research. Pediatr Res. 2020;88(2):148-150.

12. van Dorn A. COVID-19 and readjusting clinical trials. Lancet. 2020;396:523-524.

13. Asaad M, Habibullah NK, Butler CE. The impact of COVID-19 on clinical trials. Ann Surg. 2020;272:e222-e223. doi:10.1097/sla.0000000000004113

14. Talaee N, Varahram M, Jamaati H, et al. Stress and burnout in health care workers during COVID-19 pandemic: Validation of a questionnaire [published online ahead of print June 6, 2020]. J Public Heal. 2022;30:531-536.

15. Khasne RW, Dhakulkar BS, Mahajan HC, Kulkarni AP. Burnout among healthcare workers during COVID-19 pandemic in India: Results of a questionnaire-based survey. Indian J Crit Care Med. 2020;24:664-671.

16. Matsuo T, Kobayashi D, Taki F, et al. Prevalence of health care worker burnout during the coronavirus disease 2019 (COVID-19) pandemic in Japan. JAMA Netw open. 2020;3(8):e2017271. doi:10.1001/jamanetworkopen.2020.17271

17. Orrù G, Marzetti F, Conversano C, et al. Secondary traumatic stress and burnout in healthcare workers during COVID-19 outbreak. Int J Environ Res Public Health. 2021;18:337.

18. Çelmeçe N, Menekay M. The effect of stress, anxiety and burnout levels of healthcare

professionals Caring for COVID-19 patients on their quality of life. Front Psychol. 2020;11:597624.

19. Morgantini LA, Naha U, Wang H, et al. Factors contributing to healthcare professional burnout during the COVID-19 pandemic: A rapid turnaround global survey. PLoS One. 2020;15:e0238217.

20. Cravero AL, Kim NJ, Feld LD, et al. Impact of exposure to patients with COVID-19 on residents and fellows: An international survey of 1420 trainees. Postgrad Med J. 2021;97:706-715.

21. Balhareth A, AlDuhileb MA, Aldulaijan FA, Aldossary MY. Impact of COVID-19 pandemic on residency and fellowship training programs in Saudi Arabia: A nationwide cross-sectional study. Ann Med Surg. 2020;57:127-132.

22. Aziz H, James T, Remulla D, et al. Effect of COVID-19 on surgical training across the United States: A national survey of general surgery residents [published online ahead of print July 30, 2020]. J Surg Educ. 2021;78:431-439.

23. Brown NJ. Developing physician-scientists: A perspective. Trans Am Clin Climatol Assoc. 2013;124:218-229.

24. Milewicz DM, Lorenz RG, Dermody TS, Brass LF. Rescuing the physician-scientist workforce: The time for action is now. J Clin Invest. 2015;125:3742-3747.

25. Viglione G. Are women publishing less during the pandemic? Here's what the data say. Nature. 2020;581:365-366.

26. Gabster BP, van Daalen K, Dhatt R, Barry M. Challenges for the female academic during the COVID-19 pandemic. Lancet. 2020;395:1968-1970.

27. United Nations. Policy Brief: The Impact of COVID-19 on Women.

https://www.unwomen.org/en/digital-library/publications/2020/04/policy-brief-the-impact-of-covid-19-on-women. Published April 9, 2020. Accessed April 12, 2022.

28. Cui R, Ding H, Zhu F. Gender inequality in research productivity during the COVID-19 pandemic. . Manufacturing & Service Operations Management. 2022;24:707-726.
29. Collins C. Productivity in a pandemic. Science. 2020;369:603.
30. Rao RC, Dlouhy BJ, Capell BC, Akeju O. The endangered physician-scientist and COVID-19. Cell Rep Med. 2021;2:100190.
31. Infortuna C, Gratteri F, Benotakeia A, et al. Exploring the gender difference and predictors of perceived stress among students enrolled in different medical programs: A cross-sectional study. Int J Environ Res Public Health. 2020;17:6647. doi:10.3390/ijerph17186647
32. Vyas KS, Stratton TD, Soares NS. Sources of medical student stress. Educ Health. 2017;30:232-235.
33. Zvauya R, Oyebode F, Day EJ, Thomas CP, Jones LA. A comparison of stress levels, coping styles and psychological morbidity between graduate-entry and traditional undergraduate medical students during the first 2 years at a UK medical school. BMC Res Notes. 2017;10(1):93.
34. Dillon EC, Stults CD, Deng S, et al. Women, younger clinicians', and caregivers' experiences of burnout and well-being during COVID-19 in a US healthcare system. J Gen Intern Med. 2022;37(1):145–153.
35. Ettman CK, Abdalla SM, Cohen GH, Sampson L, Vivier PM, Galea S. Prevalence of depression symptoms in US adults before and during the COVID-19 pandemic. JAMA Netw Open. 2020;3:e2019686. doi:10.1001/jamanetworkopen.2020.19686

36. Rotenstein LS, Ramos MA, Torre M, et al. Prevalence of depression, depressive symptoms, and suicidal ideation among medical students A systematic review and meta-analysis. JAMA. 2016;316:2214-2236.

37. Dyrbye LN, Eacker A, Durning SJ, et al. The impact of stigma and personal experiences on the help-seeking behaviors of medical students with burnout. Acad Med. 2015;90:961-969.

38. Lauer M. Reminder of COVID-19-Related Flexibilities for NIH Grants. Extramural Nexus. National Institutes of Health. Published September 24, 2021. Accessed May 17, 2022. https://nexus.od.nih.gov/all/2021/09/24/reminder-of-covid19-related-flexibilities-for-nih-grants/

39. Macilwrait P, Bennett D. Burnout and physical activity in medical students. Ir Med J. 2018;111:707.

40. Byrom N. The challenges of lockdown for early-career researchers. Elife. 2020;9:e59634.

41. McCutcheon VE, Grant JB, Schulenberg SE. Answering the call of COVID-19: An integrated mental health response considering education, training, research, and service. Psychol Trauma. 2020;12(Suppl 1)::S284-S286. .

42. Dragisich V. Wellness and community modules in a graduate teaching assistant training course in the time of pandemic. J Chem Educ. 2020;97:3341-3345.

43. UNESCO Institute for Information Technologies in Education. Guidance on Flexible Learning During Campus Closures: Ensuring Course Quality of Higher Education in COVID-19 Outbreak. https://iite.unesco.org/publications/guidance-on-flexible-learning-during-campus-closures-ensuring-course-quality-of-higher-education-in-covid-19-outbreak/. Published 2020. Accessed April 12, 2022.

44. Gallagher TH, Schleyer AM. "We signed up for this!"—Student and trainee responses to the Covid-19 pandemic. N Engl J Med. 2020;382(25):e96. doi:10.1056/nejmp2005234

45. Johnson RL, Coleman RA, Batten NH, Hallsworth D, Spencer EE. The quiet crisis of PhDs and COVID-19: Reaching the financial tipping point. Research Square. https://www.researchsquare.com/article/rs-36330/v2. Published July 8, 2020. Accessed April 12, 2022.

46. Tay A. Struggling to get started. Elife. 2020;9:e59147.

47. McCauley DJ. Research and funding in the time of COVID-19. CSA News. 2020;65:22-26.

48. Majowicz SE. What might the future bring? COVID-19 planning considerations for faculty and universities. Epidemiol Infect. 2020;148:e92.

49. Farkas AH, Bonifacino E, Turner R, Tilstra SA, Corbelli JA. Mentorship of women in academic medicine: A systematic review. J Gen Intern Med. 2019;34:1322-1329.

50. Cross M, Lee S, Bridgman H, Thapa DK, Cleary M, Kornhaber R. Benefits, barriers and enablers of mentoring female health academics: An integrative review. PLoS One. 2019;14(4):e0215319.

Table 1

Demographic Characteristics of Respondents by Cohort, Survey of Physician-Scientist Trainees and Faculty at 120 U.S. Institutions, April–June 2020

Characteristic	Medical students (n = 679)	Graduate students (n = 676)	Residents/ fellows (n = 274)	Faculty (n = 300)	*P* value
Mean age (range), years	26.7 (21-38)	27.5 (21-44)	33.2 (19-47)	40.6 (30-51)	< .001
Gender, no. (%)					
Female	370 (55)	349 (52)	121 (45)	156 (52)	.046
Male or other[a]	305 (45)	326 (48)	150 (55)	144 (48)	
Ethnicity, no. (%)					.003
Hispanic or Latino/a	50 (7)	53 (8)	21 (8)	18 (6)	
Race, no. (%)					
White	392 (58)	391 (58)	160 (58)	200 (67)	.043
Asian	173 (25)	149 (22)	71 (26)	49 (16)	
Black or African American	30 (4)	26 (4)	9 (3)	11 (4)	
Other	84 (12)	110 (16)	34 (12)	40 (13)	
Region, no. (%)					< .001
Midwest	162 (24)	203 (30)	65 (24)	20 (7)	
Northeast	229 (34)	204 (30)	119 (43)	111 (37)	
South/Southeast	200 (29)	170 (25)	57 (21)	143 (48)	
West	86 (13)	93 (14)	32 (12)	25 (8)	
Other	2 (0)	6 (1)	1 (0)	1 (0)	
Dual degree, no. (%)	495 (73)	648 (96)	175 (64)	109 (36)	< .001
Pandemic effects, no. (%)					
Training/education affected (virtual classrooms, virtual patient encounters)	615 (91)	659 (97)	167 (61)	152 (51)	< .001
Career affected (tenure track, graduation, exam timing)	250 (37)	267 (39)	87 (32)	21 (7)	< .001
Conducting research/scholarly activity	600 (88)	633 (94)	212 (77)	229 (76)	< .001
Financial difficulties (job loss, pay cut, partner job loss, medical debt)	193 (28)	225 (33)	99 (36)	133 (44)	< .001
Infected or symptoms of COVID-19	48 (7)	55 (8)	44 (16)	41 (14)	< .001
Personal life affected	538 (79)	480 (71)	175 (64)	211 (70)	< .001
Research productivity affected[b]	487 (72)	572 (85)	183 (67)	191 (64)	< .001

Characteristic	Medical students (n = 679)	Graduate students (n = 676)	Residents/ fellows (n = 274)	Faculty (n = 300)	*P* value
Research/scholarly activity affected	347 (51)	578 (86)	103 (38)	138 (46)	< .001
Social isolation experienced	300 (44)	456 (67)	163 (59)	181 (60)	< .001
Stress experienced	552 (81)	583 (86)	222 (81)	253 (84)	.059

[a]Other responses included "nonbinary," "gender-queer," "male/agender," and "prefer not to answer."
[b]And/or medical training.

Table 2

Factors Associated With Stress[a] by Respondent Cohort, Survey of Physician-Scientist Trainees and Faculty at 120 U.S. Institutions, April–June 2020[b]

Characteristic	Stress group, no. (%)[c]	No stress group, no. (%)[c]	*P* value
Medical students (n = 679)	(n = 552)	(n = 127)	
Gender			
Female	314 (57)	56 (45)	.013
Male or other	236 (43)	69 (55)	
Training/education affected (virtual classrooms, virtual patient encounters)	552 (100)	63 (50)	< .001
Career affected (graduation, exam timing)	227 (41)	23 (18)	< .001
Conducting research/scholarly activity	539 (98)	61 (48)	< .001
Financial difficulties (job loss, pay cut, partner job loss, medical debt)	186 (34)	7 (6)	< .001
Infected or symptoms of COVID-19	47 (9)	1 (1)	.002
Personal life affected	489 (89)	49 (39)	< .001
Research productivity affected[d]	447 (81)	40 (32)	< .001
Research/scholarly activity affected	323 (59)	24 (19)	< .001
Social isolation experienced	295 (53)	5 (4)	< .001
Graduate students (n = 676)	(n = 583)	(n = 93)	
Career affected (graduation, exam timing)	252 (43)	15 (16)	< .001
Changed research to COVID-19 or changed specialty due to COVID-19	74 (13)	3 (3)	.008
Conducting research/scholarly activity	580 (100)	53 (57)	< .001
Financial difficulties (job loss, pay cut, partner job loss, medical debt)	214 (37)	11 (12)	< .001
Personal life affected	445 (76)	35 (38)	< .001
Research/scholarly activity affected	534 (92)	44 (47)	< .001
Research productivity affected[d]	535 (92)	37 (40)	< .001
Social isolation experienced	432 (74)	24 (26)	< .001
Laboratory type			
Only dry	77 (13)	11 (12)	< .001
Mixed/none	111 (19)	48 (52)	
Only wet	395 (68)	34 (37)	
Research field			
Biological sciences	473 (81)	42 (45)	< .001
Computer and information science and engineering	18 (3)	2 (2)	
Mixed/none	92 (16)	49 (53)	
Residents/fellows (n = 274)	(n = 222)	(n = 52)	
Mean age (range)	33.5 (19-45)	32 (23-47)	< .001

Characteristic	Stress group, no. (%)[c]	No stress group, no. (%)[c]	*P* value
Dual degree	152 (69)	23 (44)	.001
Training year			< .001
Fellowship	90 (41)	10 (19)	
Residency	72 (32)	30 (58)	
Internship	30 (14)	10 (19)	
Postdoctoral research	29 (13)	0 (0)	
Postgraduate nonacademic	1 (1)	2 (4)	
Career affected (tenure track, graduation, exam timing)	87 (39)	0 (0)	< .001
Changed research to COVID-19 or changed specialty due to COVID-19	43 (19)	0 (0)	< .001
Conducting research/scholarly activity	206 (93)	6 (12)	< .001
Financial difficulties (job loss, pay cut, partner job loss, medical debt)	99 (45)	0 (0)	< .001
Infected or symptoms of COVID-19	44 (20)	0 (0)	< .001
Patient care affected	208 (94)	6 (12)	< .001
Personal life affected	171 (77)	4 (8)	< .001
Research/scholarly activity affected	101 (46)	2 (4)	< .001
Research productivity affected[d]	179 (81)	4 (8)	< .001
Social isolation experienced	159 (72)	4 (8)	< .001
Training/education affected (virtual classrooms, virtual patient encounters)	162 (73)	5 (10)	< .001
Faculty (n = 300)	(n = 253)	(n = 47)	
Changed research to COVID-19 or changed specialty due to COVID-19	44 (17)	0 (0)	.002
Conducting research/scholarly activity	227 (90)	2 (4)	< .001
Financial difficulties (job loss, pay cut, partner job loss, medical debt)	133 (53)	0 (0)	< .001
Infected or symptoms of COVID-19	41 (16)	0 (0)	.003
Patient care affected	239 (95)	2 (4)	< .001
Personal life affected	209 (83)	2 (4)	< .001
Research/scholarly activity affected	136 (54)	2 (4)	< .001
Research productivity affected[d]	190 (75)	1 (2)	< .001
Social isolation experienced	180 (71)	1 (2)	< .001
Training/education affected (virtual classrooms, virtual patient encounters)	151 (60)	1 (2)	< .001

[a]The stress outcome was defined by answering "agree" or "strongly agree" to one or more of the following questions in the survey: "The COVID-19 pandemic has caused me a significant amount of stress, anxiety, hopelessness and/or depression," "The COVID-19 pandemic has caused sleep problems, decreased energy, changes in appetite, difficulty concentrating and/or restlessness," "Uncertainty of not being able to finish my research or to graduate is a great source of stress," and "Worrying about my own health is a great source of stress."
[b]The full survey tool is available as Supplemental Digital Appendix 1 at [LWW INSERT LINK TO SD APP 1].
[c]Values are no. (%) unless otherwise indicated.
[d]And/or medical training.

Table 3

Factors Associated With Impaired Productivity[a] by Respondent Cohort, Survey of Physician-Scientist Trainees and Faculty at 120 U.S. Institutions, April–June 2020[b]

Characteristic	Productivity affected, no (%)[c]	Productivity not affected, no (%)[c]	*P* value
Medical students (n = 679)	(n = 487)	(n = 192)	
Training/education affected (virtual classrooms, virtual patient encounters)	487 (100)	128 (67)	< .001
Career affected (graduation, exam timing)	195 (40)	55 (29)	.006
Conducting research/scholarly activity	477 (98)	123 (64)	< .001
Financial difficulties (job loss, pay cut, partner lose job, medical debt)	161 (33)	32 (17)	< .001
Personal life affected	430 (88)	108 (56)	< .001
Research/scholarly activity affected	292 (60)	55 (29)	< .001
Social isolation experienced	261 (54)	39 (20)	< .001
Stress experienced	447 (92)	105 (55)	< .001
Graduate students (n = 676)	(n =572)	(n = 104)	
Mean age (range), years	27.4 (21-40)	28.3 (21-44)	.003
Dual degree	553 (97)	95 (91)	.027
Conducting research/scholarly activity	570 (100)	63 (61)	< .001
Financial difficulties (job loss, pay cut, partner job loss, medical debt)	208 (36)	17 (16)	< .001
Personal life affected	441 (77)	39 (38)	< .001
Research/scholarly activity affected	533 (93)	45 (43)	< .001
Social isolation experienced	417 (73)	39 (46)	< .001
Stress experienced	535 (94)	48 (46)	< .001
Laboratory type			
Only dry	60 (11)	28 (27)	< .001
Mixed/none	102 (19)	50 (48)	
Only wet	403 (71)	26 (25)	
Research field			
Biological sciences	478 (84)	37 (36)	< .001
Computer and information science and engineering	11 (2)	9 (9)	
Mixed/none	83 (15)	58 (56)	
Residents/fellows (n = 274)	(n = 183)	(n = 91)	
Mean age (range), years	33.7 (22-43)	32.2 (19-47)	< .001
Dual degree	132 (72)	43 (47)	< .001
Training year			< .001
Fellowship	78 (43)	22 (24)	
Residency	58 (32)	44 (48)	
Internship	21 (12)	19 (21)	

Characteristic	Productivity affected, no (%)[c]	Productivity not affected, no (%)[c]	*P* value
Postdoctoral research	26 (14)	3 (3)	
Postgraduate nonacademic	0 (0)	3 (3)	
Career affected (tenure track, graduation, exam timing)	80 (44)	7 (8)	< .001
Changed research to COVID-19 or changed specialty due to COVID-19	35 (19)	8 (9)	.027
Conducting research/scholarly activity	174 (95)	38 (42)	< .001
Financial difficulties (job loss, pay cut, partner job loss, medical debt)	85 (46)	14 (15)	< .001
Patient care affected	171 (93)	43 (47)	< .001
Personal life affected	147 (80)	28 (31)	< .001
Research/scholarly activity affected	95 (52)	8 (9)	< .001
Social isolation experienced	132 (72)	31 (34)	< .001
Stress experienced	179 (98)	43 (47)	< .001
Training/education affected (virtual classrooms, virtual patient encounters)	142 (78)	25 (28)	< .001
Faculty (n = 300)	(n = 191)	(n = 109)	
Mean age (range), years	41 (32-51)	40 (30-51)	.033
Dual degree	87 (46)	22 (20)	< .001
Career affected (tenure track, graduation, exam timing)	18 (9)	3 (3)	.029
Changed research to COVID-19 or changed specialty due to COVID-19	34 (18)	10 (9)	.042
Conducting research/scholarly activity	182 (95)	47 (43)	< .001
Financial difficulties (job loss, pay cut, partner job loss, medical debt)	97 (51)	36 (33)	.003
Patient care affected	138 (72)	53 (49)	< .001
Personal life affected	165 (86)	46 (42)	< .001
Research/scholarly activity affected	130 (68)	8 (7)	< .001
Social isolation experienced	141 (74)	40 (37)	< .001
Stress experienced	190 (100)	63 (58)	< .001
Training/education affected (virtual classrooms, virtual patient encounters)	119 (62)	33 (30)	< .001

[a]The impaired productivity outcome was defined by the respondent answering ”agree” or “strongly agree” to at least one of the following questions: “My research productivity/medical training will be negatively impacted in the short-term (<2 months)” and “My research productivity/medical training will be negatively impacted in the long-term (> 2 months).”
[b]The survey tool is available as Supplemental Digital Appendix 1 at [LWW INSERT LINK TO SD APP 1
[c]Values are no. (%) unless otherwise indicated.
[d]And/or medical training.